SCIENCE IN SMALL STEPS

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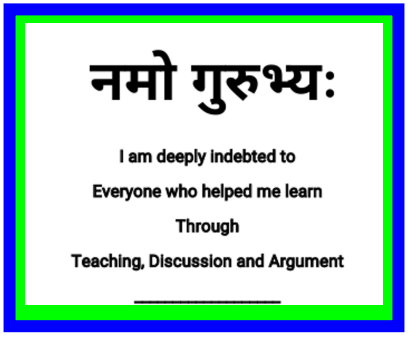
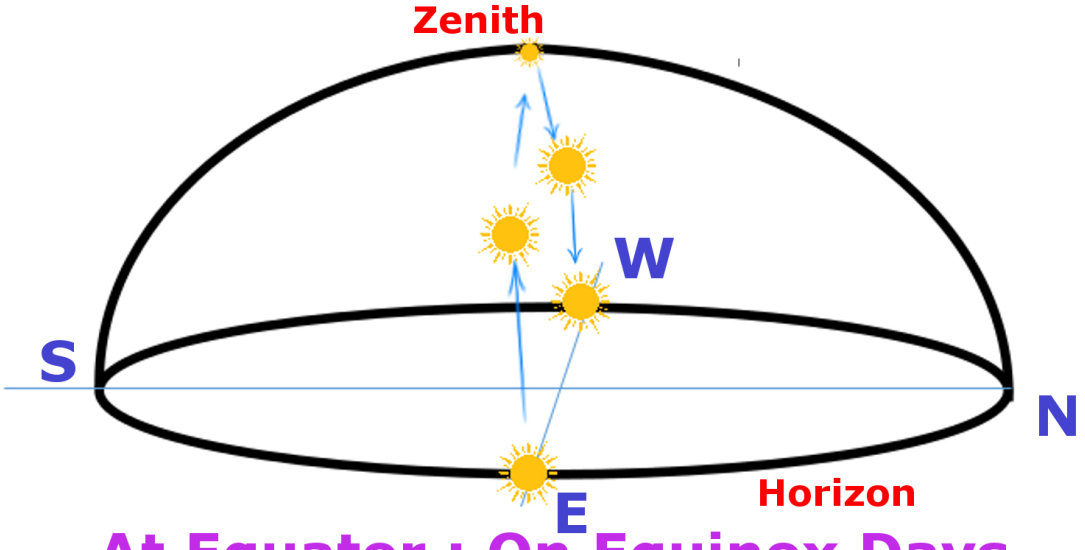


Science is the study of the world around us. It is extremely useful not only to "know" science but also to understand "how well we do know it". This second attribute of science is very rarely discussed in elementary books on science. The introductory books on science also do not focus on the interrelationships between various aspects of science. These are most likely seen as extremely complex and beyond the reach of the beginners. This book takes on these challenges. It describes science as a series of interlinked ideas and goes on to describe how anyone can easily evaluate qualitatively, "how confident" one can be that a particular conclusion of science is true and how useful it is in practice. At the same time, the book makes no demand whatsoever of a prior knowledge of science. Even the language has been made as simple as possible. Hopefully, this attempt would be found useful. Dr. S. Mohan has been the consistent source of inspiration and assistance for all my writings and I am eternally grateful to him.

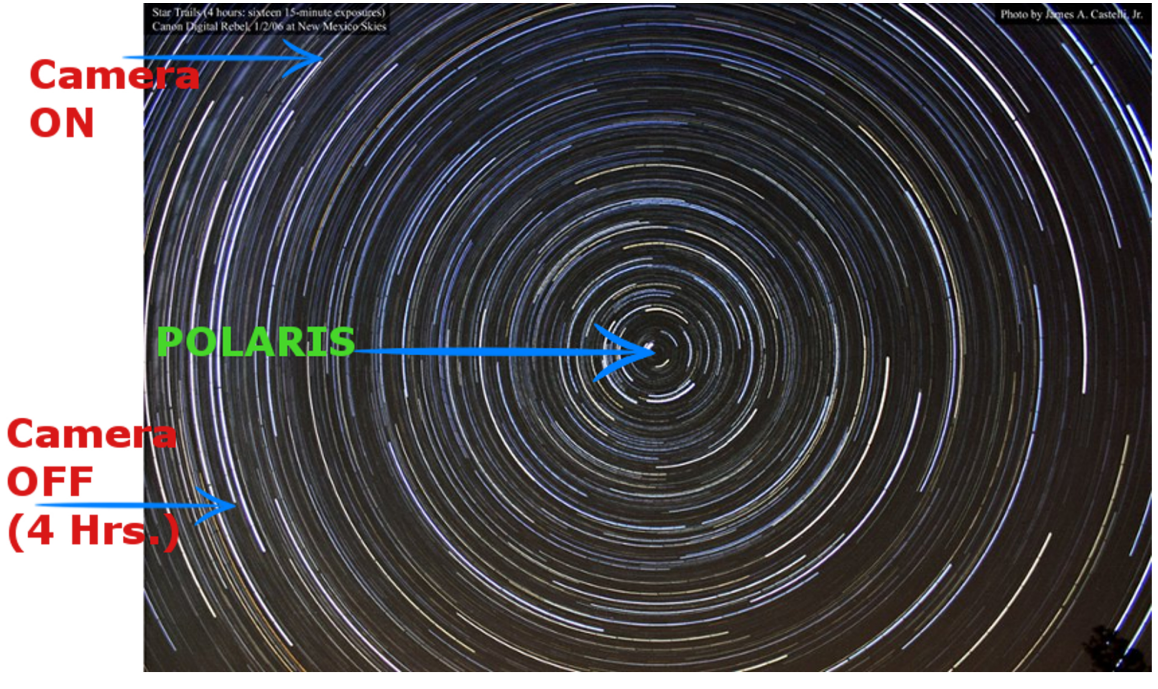
S T Lakshmikumar



At Equator : On Equinox Days

12 hours sunlight at all places on the earth

We say that the sun rises in the east and sets in the west. But sunrise and sunset do not occur everyday at the same place on the horizon. How often would the sun rise exactly in the east, reach the zenith, the point of the sky exactly overhead at noon and set exactly in the west? {Picture above}. The surprising answer is, only on two days of the year and that too only if you are on the equator. The days are usually 20th March and 22nd or 23rd September. These days are called the EQUINOXES (equal night in Latin) because, on these days, length of the day and the night are nearly equal at al the places on the earth.



But why is the direction of sun rise on the equinox day considered exact or true east? North of the equator, the stars appear to rotate around the pole star. When the movement of the stars over several hours is photographed, each star looks like a part of a circle. {Picture above} And at the centre of all these circles is the pole star or Polaris. That is the true north. The direction exactly at right angles to the true north is the true east. North of the equator, following the equinox day in March, the position of sunrise on the horizon keeps

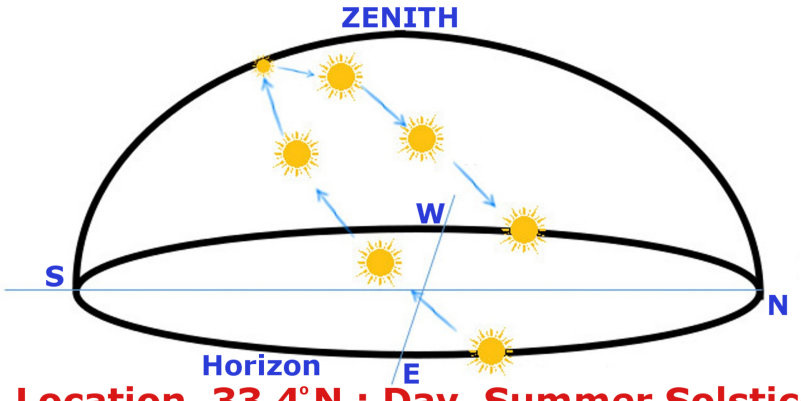
Summer Solstice 14 hours of Sunlight

Equinoxes (At 33.4N) 12 hours of Sunlight

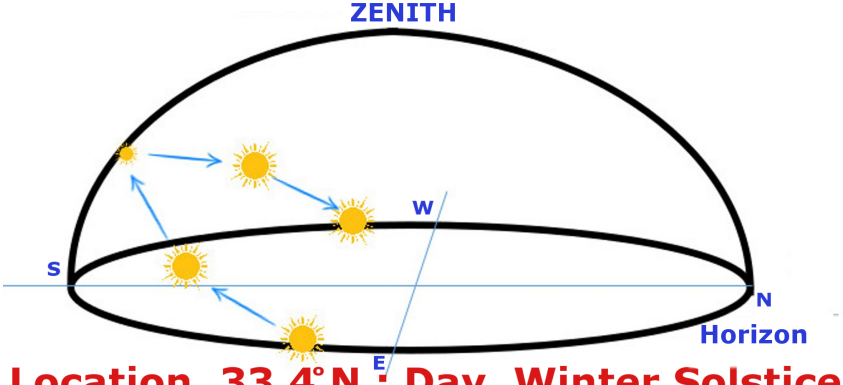
Winter Solstice 10 hours of Sunlight

moving north. This movement stops between 20th to 23nd June and the sunrise position on the horizon starts to move south. {Picture above} The sunrise returns to true east on the equinox day in September. The southern movement continues till around 20th to 23rd December. Then the movement northward starts again and the sunrise returns to exact east on the equinox day in March. The traditional Indian calculations asserted that the northward movement of the sun coincides with its entry into the zodiac house of Capricorn on January 14th or 15th. But the movement can be seen after 20th to 23rd December. This photograph at 33.4°N of the equator was possible because the horizon and the movement of the sunrise over the year was visible. When the sunrise moves towards north in areas north of the equator, it moves towards south in areas south of the equator.

When sunrise occurs north of true east, the sun set is also north of true west. But the sun does not reach the zenith. The path of the sun in the sky is long. {Picture right top}. There can be, for example, 14 hours of daylight and only ten hours of night. It is a hot summer day, north of the equator. About six months later, sun rise is south of true east and sun set south of true west. The path of the sun in the sky is short and the sun at midday is very far from the zenith. It is a cold winter day. {Picture right bottom} As one moves further from the equator, positions of sun rise and sun set on the horizon are closer to each other in winter and days become shorter.

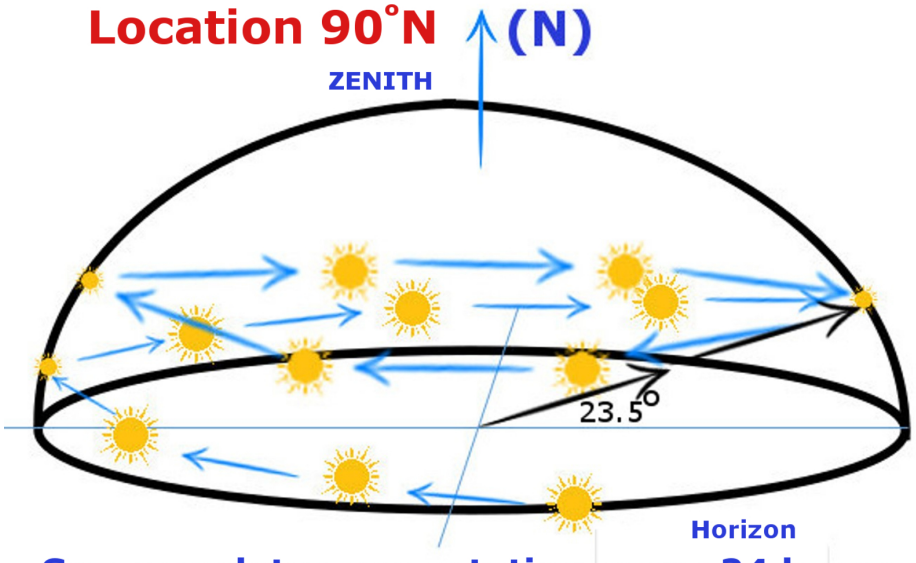


Location, 33.4°N : Day, Summer Solstice
Sunrise to sunset , 14 hours



Location, 33.4°N : Day, Winter Solstice
Sunrise to sunset, 10 hours

At the north pole, the Polaris is right overhead and there is no



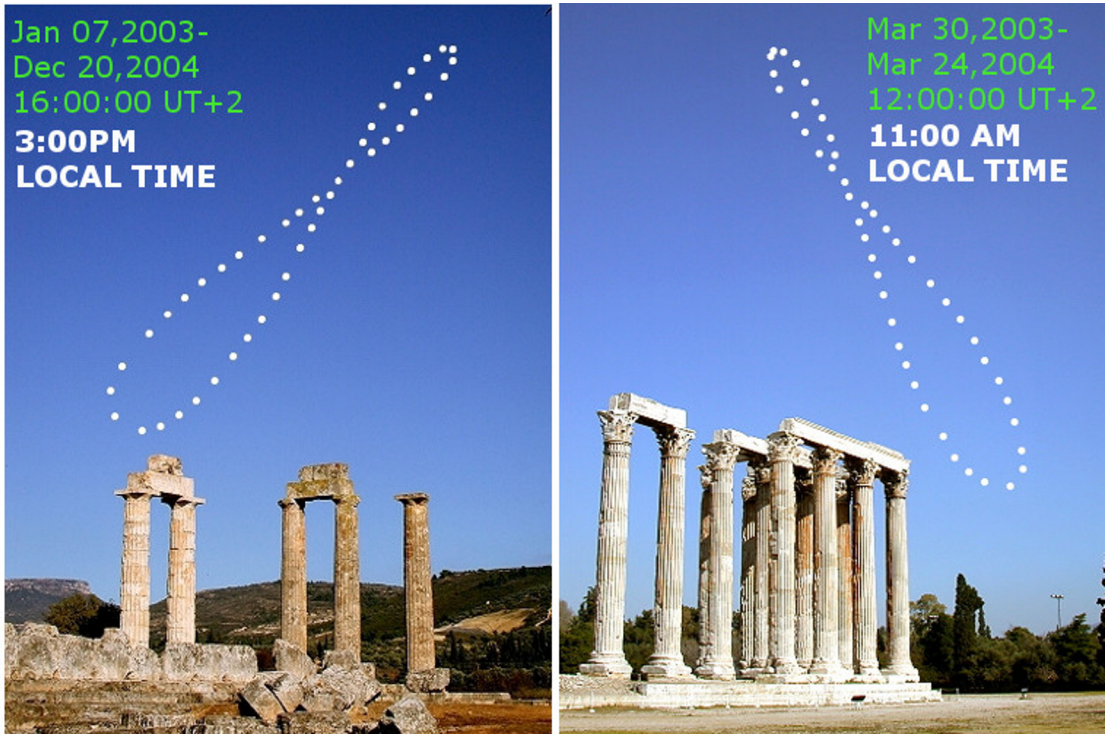
true north. So there is no way to know the true east or the true west. At the north pole, from equinox in September to the equinox in March, the sun never rises above the horizon in any direction. That is the six month long night. During these six months, at the south pole, the sun is always above the horizon. This is the six month long day. But during these six months, the sun completes one rotation around the pole every 24 hours. {Picture above} This is the meaning of the statement that there is no true east or west. During the first three months of this period, the sun slowly climbs higher above the horizon after every rotation.

During the next three months, the sun moves closer to the horizon after every rotation. After the equinox in March, the sun slips entirely below the horizon when seen from the south pole and the night starts. When the six month long day starts at the north pole, the six month long night begins at the south pole. On equinox days, even at the poles, the sun peeps above the horizon for approximately twelve hours.

ATHENS GREECE

Highest : Summer Solstice

Lowest : Winter Solstice



If the sun's position in the sky is carefully noted everyday, at the same place, at the same time of the day, it will become obvious that the position of the sun changes from day to day. Such a measurement, continued for one year, is shown in the pictures. {Picture page opposite} The figure of eight is called an analemma. The results of this experiment will always form a figure of eight no matter where the experiment is done and at what time of the day. But the relative sizes of the two closed loops and their angle to the ground will change. In the anelemna taken north of the equator, the highest point is the day on which the sunrise starts moving south on the horizon. The lowest point is the day on which sunrise starts moving north. Except for the one point where the lines cross, the sun is at a given point in the sky only once a year.

A simple question, where in the sky is the sun at a given time and place gives interesting details as one observes carefully. Careful observation is the first step of modern science. A good scientific theory should help one to calculate the position and compare it with experiments.

It is easy to keep shouting that the earth is flat. It is impossible to explain all the sun positions described above on that basis. Guesses and conjectures by ancient philosophers cannot do it either. Only Newton's law of gravitation can.